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Shell Coremaking

To be a commercial success, shell moulding has to produce castings of such a quality that they can compete—through according an economic price—with those made by conventional means. The most difficult obstacle that has to be overcome is the considerable margin in favour of established practice when considering the basic cost of raw materials. Shell-moulding sands, containing 5 per cent. or more of resin, are much more expensive than either naturally-bonded or synthetic moulding sands. Therefore, makers of shell-moulded castings must look to a reduction in the costs of labour in handling and fettling, and of overheads—due to the small amount of manufacturing area and plant, and the quantity of machinery used. The most important factor operating against this new technique is the high capital expenditure that has been made in recent years through the mechanizing of the industry. However, in most cases, there has been a smaller investment in the coreshop than the moulding department.

In the case of coremaking, all the above considerations apply, with the exception that the margin between costs of raw materials is narrowed, a factor emphasized when making medium-to-large cores; shell cores are hollow and weigh so much less. Taking it for granted that means are available for filling and removing the surplus sand from a heated metal corebox, then, on stripping, the core can be used straight away in either a shell or a green-sand mould. It is interesting to see what could be eliminated in comparison with conventional practice. Primarily core carriers would no longer be needed, or the conveyor leading to the drying stove; the loading of the continuous drying stove, its operation and the removal of dried cores would be rendered unnecessary, as would the inspection, sometimes blacking and re-stoving of cores—with the necessary handling. Much of this processing, no doubt, would be replaced by the furnishing of stillages for the transfer of the cores to the mould-assembly stations.

Whilst the prospects in shell moulding still appear to be bright, as the techniques of the process are being developed, snags overcome, and costs reduced, yet we deem those for shell coremaking even more impressive. With its development, there should be the same reduction in manufacturing area, greater precision, and reduced handling. Moreover, to-day, experiments have shown that the waste shell sand can be economically recuperated. In any case, we should imagine that shell core-sand introduced at the knock-out into the system sand would be less detrimental than most other types. The only residue remaining after combustion of the resin would appear to be a trace of graphite. We do not for a moment imagine that a fully developed shell coremaking process will eliminate the older processes but it should find a useful niche in the foundry practice of the not too distant future. Here, then, is a real need for industrial research, alike in the development of machines, the actual process and the acquisition of data as to sand recuperation. A final word of warning is that, before embarking on any new project, it is essential to know existing costs in order to establish proper comparisons. The modern foundryman does not buy a " pig in a poke."

Shell-moulding Association

The many problems which confront this new and enterprising industry, including the patent position, technical development, commercial considerations, show the need for co-operation and consultation with those serving the industry as suppliers of material or manufacturers of machines. Shell moulders are not confined to any one branch of founding, ferrous or non-ferrous, and it thought, therefore, that a shell-moulding association should be formed. The suggested objects of the association are:—

1. To collate and disseminate information on shell moulding and allied processes which will assist members to develop and commercially exploit the process or processes.
2. To create facilities with a view to advising the members on technical, commercial and legal aspects of the shell-moulding process or allied processes.
3. To promote co-operation between the shell moulder and the manufacturers or producers of all plant and materials which are used or may be used in the shell-moulding process.
4. To take such collective action as may be necessary to safeguard the interests of members.

A general meeting will therefore be held in the Grosvenor Room, Grand Hotel, Birmingham, on Wednesday, June 30, 1954, at 2.30 p.m., when the proposal to form a shell-moulding association will be considered and a draft constitution submitted. It would be greatly appreciated if readers desiring to attend would kindly advise the secretaries (Heathcote & Coleman, 69, Harborne Road, Edgbaston, Birmingham, 15) so that adequate arrangements can be made.

Dinner

IRON AND STEEL INSTITUTE

On May 26, in the Great Hall at Grosvenor House, Park Lane, was held the annual dinner of the Iron and Steel Institute, with the president, the Hon. R. G. Lyttelton, in the Chair. Over 1,200 members and guests attended. The high table was graced by a number of gentlemen connected directly or indirectly with foundries, including:—The Rt. Hon. Harold Macmillan, P.C., M.P., H.E. René Massigli, Sir A. McCance, D.SC., F.R.S., Captain H. Leighton Davies, C.B.E., Sir A. Forbes, Sir L. Bragg, O.B.E., M.C., F.R.S., R. Mather, Lt.-Col. Lord Dudley Gordon, D.S.O., Sir D. Brunt, F.R.S., Sir Harry Pilkington, R. M. Shone, C.B.E., Sir William Larke, K.B.E., Dr. L. B. Pfeil, O.B.E., F.R.S., E. W. Senior, Sir C. Goodeve, O.B.E., D.SC., F.R.S., K. Marshall, Sir L. Evans, C.B.E., E. Taylor-Austin, Professor J. A. S. Ritson, D.S.O., M.C., O.B.E., E. Longden, Dr. A. W. Chapman, Sir H. Roxbee Cox, Dr. J. G. Pearce, O.B.E., and K. Marshall.

After the loyal toast, the "Iron and Steel Institute and the Industry" was proposed by the Rt. Hon. Harold Macmillan, P.C., M.P., and responded to by the president. "The Guests" was proposed by Sir Charles Bruce-Gardner, BT., and the Very Rev. A. C. Don, K.C.V.O., replied.

AT THE ANNUAL GENERAL MEETING of the Midland section of the Institute of Vitreous Enamellers, May 6, 1954, the following officers were elected for the next session, taking office immediately after the Autumn conference: As *chairman*, Mr. A. G. Read; as *vice-chairman*, Mr. Darrall Baldwin; as *committee*, Mr. L. Bayliss, Mr. W. Ball, and Mr. G. H. Legg; as *secretary*, Mr. D. Sleath; and *lanternist*, Mr. A. Rodway.

Foundrymen at Play

Several functions in which foundrymen golfing enthusiasts participated took place recently. The first was when the golfing section of Allied Ironfounders' Social and Sports Club held their annual outing over the Callander Golf Course, and 61 competitors took part in 36-holes competitions. Although the weather was unfavourable everyone seemed to enjoy the function. Winners of the prizes and various trophies included the following:—36-holes scratch competition for the Glasgow Cup—J. J. Miller (M. Cockburn); 36-holes handicap for the Kennard Trophy—W. Paton (Callendar Abbots); inter-works team 36-holes handicap for the Steven Cup—M. Cockburn and Company, Limited, and Dobbie, Forbes and Company, Limited, equal; inter-works team 36-holes scratch for the Callander Cup—M. Cockburn and Company, Limited; 18-holes handicap for Star Medal—C. Walker (Falkirk Iron Company). Luncheon and tea were served in the clubhouse and after tea Mr. R. G. Sinclair, director of the Falkirk Iron Company, Limited, presented the trophies and prizes.

Then, on Friday last, Bradley and Foster, Limited, of Darlaston, held their annual golf competition at the Whittington Barracks Club course for the McKenna Cup. Twenty-eight competitors enjoyed their 18-hole round. Although the weather deteriorated rapidly towards the end of the afternoon, any dampness the competitors might have experienced was quickly dispelled at "the nineteenth hole," where tea was provided. Players were joined by other friends and guests of the company to a total of 60 at dinner afterwards in the George Hotel, Lichfield, presided over by Dr. J. E. Hurst, C.B.E., J.P., managing director, deputising for Mr. T. A. McKenna, his chairman. The award of the trophy was made by the Mayor of Lichfield, Alderman A. L. Garratt, to Mr. R. A. Stiles, the winner, with a net score of 70. Mr. L. Foster and Mr. R. Church were second and third respectively. The evening was punctuated with anecdotes and choral entertainment and concluded with a vote of thanks to the hosts.

The third golfing function was but one of a series of sporting events included in the centenary celebrations of Smith and Wellstood, Limited, of Bonnybridge, (dealt with elsewhere in this issue) the prizes for which were distributed on May 28. The golfing award was made to Mr. A. Gibson. Other sports competitions in the series included carpet and rink bowls, darts, billiards, dominoes, fishing and five-a-side football. The final function of the centenary celebrations was a gala on May 29 for some 600 children of employees of the firm (and their associates, Mitchell Russell & Company, Limited).

Forty Years Ago

The June issue of the FOUNDRY TRADE JOURNAL for 1913 contained a report of the annual general meeting of the Institute of British Foundrymen. By that time it had 974 members and the Scottish branch was the largest, with a membership of 184. Mr. S. A. Gimson was the president with Mr. W. Mayer and Mr. J. Ellis as vice-presidents. There was a full-length illustrated description of the B.T.-H. foundry at Rugby, which showed a quite good system of cupola charging. It is noticeable that already overalls were replacing moleskins as moulders' working clothes. The foundries of S. Russell & Sons, and the Midland Railway works at Derby, were similarly dealt with. The former was then already fifty years old.

Some Aspects of Shell-moulding Technique

By D. F. Bailey

As this Paper has been written by a foundryman for foundrymen, it is assumed that the reader has some conception of the basic principles of shell moulding. By now, hundreds of foundrymen in this country have looked into the shell-moulding process to see if it may have anything to offer for their particular class of founding, and many have introduced the process on a permanent basis, whilst others are operating pilot plants or contemplating one. The purpose of this Paper is to pass on some experiences of pilot-plant operation which may be of interest to the two latter categories, but it is not possible to cover every phase of shell-moulding. The basic principles of shell-moulding hold good for a hand-operated set-up as well as a fully automatic machine and it is perhaps best to gain that vital first-hand experience of how to make good shells and castings on a small hand lay-out.

Shell-making Materials

The most important factor controlling the casting surface finish is the sand grain size and distribution, because even the best of sands will produce poor surface finishes if the grains forming the shell are loosely packed due to bad dumping. British Standard sieve gradings of some shell-moulding sands are shown in Table I and it may be noticed that prior to the advent of shell moulding the foundry industry had but little use for such fine materials as Redhill grade H. Due to their fineness, the permeability was much too low for most conventional cores and moulds. The Author has tested many sands, but most of them, particularly the popular coremaking sands, are insufficiently fine to produce a good casting skin finish. Redhill F and the S.M. sand may be regarded as extenders.

Figs. 1 and 2 show strength and permeability graphs and it is interesting to note the effect of the coarser grade F sand, in the case of Redhill sand mixtures, on shell strength and permeability. The permeability results quoted in Fig. 2 were carried out by reducing a standard 2 in. dia. by 2 in. high test-piece of cured sand/resin mixture in height by ¼-in. stages. The permeability determinations were made on a Ridsdale machine, the test-pieces being held in a dry-sand type of permeability tube. In every case, the mercury seal was level with the test-piece under determination. Whilst it is appreciated

TABLE I.—*Sieve Tests on Sands Used for Shell Moulding*

	Per cent. retained on B.S. sieve number.								
	44	60	85	100	120	150	170	200	<200
Redhill H	—	0.6	1.6	4.5	12.5	27.3	27.0	11	15
Redhill F	10.1	34.0	35.8	9.4	4.0	2.2	1.3	0.6	0.5
S.M. sand (Stoke-on-Trent)	—	0.1	7.5	23.0	25.8	30.5	9.0	2.2	1.4

*This Paper was awarded first prize in the Jubilee Competition of the Institute of British Foundrymen. The Author is employed in the research and development department of Bakelite Limited and is now senior vice-president of the Coventry section of the Institute of British Foundrymen.

FIG. 1.—*Influence of sand grading on transverse strength; the p.-f. resin constant at 5 per cent.*

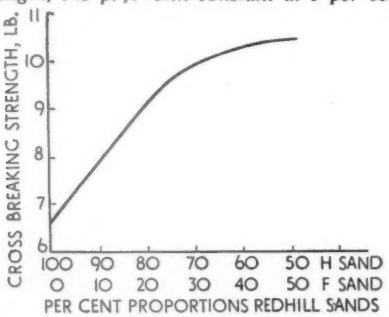


FIG. 2.—*Permeability values according to thickness for two shell-moulding mixtures.*

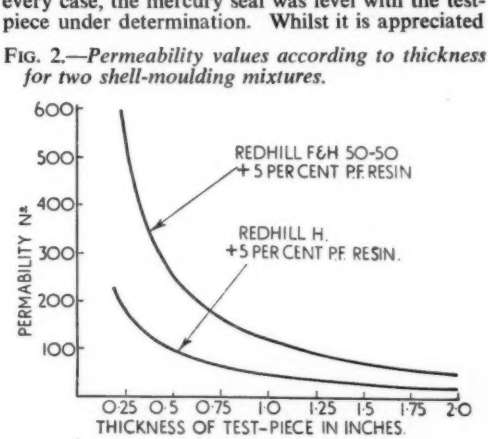


FIG. 3.—*View looking down into an open mixer suitable for resin sands.*

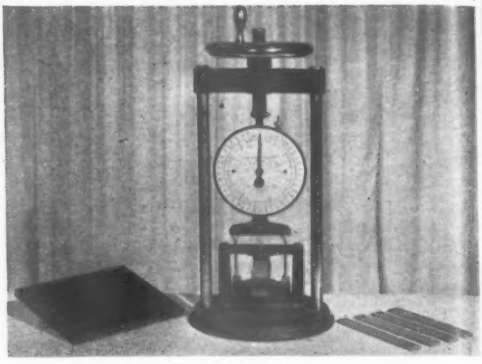


FIG. 4.—*Apparatus and test-bars for the cross-breaking strength tests on resin-bonded sand.*

that, upon altering the height of a standard test-piece, the results obtained are no longer true A.F.S. figures; the result does, however, enable a comparison to be made regarding the ability of various sand/resin mixtures to pass gases. The permeability of the shell affects some classes of work, and reference is made to this further in the text.

Typical Mixtures

The Author's practice has been confined to phenolic or p.-f. resins, as these have high strength, do not break down too early during casting and do not give off objectionable fumes; this latter item is obviously of considerable importance. The following mixtures have been used very successfully, for the casting of high-duty-iron air-cooled cylinders in unbacked shells $\frac{5}{16}$ in. thick.

Mix No. 1:

50 parts by weight Redhill F sand;
50 parts by weight Redhill H sand;
3½ parts by weight high strength p.-f. resin;
0.05 parts by weight of a wetting agent.

Whilst the small percentage of wetting agent is insufficient entirely to suppress dusting, it does prevent undue sand/resin separation during working. It has been found that when a wetting agent has been added in sufficient quantity to achieve total dust suppression there is some deterioration of the surface finish of the casting. This is attributed to the wetter mix not being as flowable as the drier one, as in the case of wetting agents of the paraffin class a minimum of 0.5 per cent. is required for total suppression.

Where even better surface finishes are required or the alloy is very searching, the proportion of fine sand may be increased. The mixture used for vertical pouring of iron camshafts with a top-running system in unbacked shells $\frac{5}{16}$ in. thick, and where the total head of metal was 26 in., was:

Mix No. 2:

100 parts by weight Redhill H sand;
6 parts by weight high-strength p.-f. resin;
0.05 parts by weight of wetting agent.

As a sand becomes finer, so the amount of resin necessary for the required shell strength increases. A very good alternative to the No. 2 mix, which produces an almost equal surface finish and conserves the expensive fine sand, is:

Mix No. 3:

75 parts by weight SM sand;
25 parts by weight Redhill H sand;
5 parts by weight high-strength p.-f. resin;
0.05 parts by weight of wetting agent.

FIG. 5.—*Dump bucket used for experimental techniques. It is* 27 *in. deep and takes a patternplate* 20 *by* 16 *in. max.*

FIG. 6.—*Shell-half showing the torn-edge defect.*

Mixing

In order to make good quality shells, it is essential to use an efficient mixer and it is the Author's opinion that good mixing cannot be obtained with tumbling. A machine with a good strong rubbing action which operates without scattering the contents over a large area is preferred. Fig. 3 shows the inside of a mixer which has been found to give very good results and has an overall mixing cycle of 5 min. A period of two and a half minutes is required to mix the sand and wetting agent together prior to the resin addition, when a further 2½ minutes' mixing is required. Should the mixture be left in with the mixer running for about 20 minutes, the temperature of the contents will reach approximately 40 deg. C. which indicates the presence of friction. This rise in temperature does not produce any deterioration in the properties of the sand/resin mixture. Bad mixing can be responsible for: (*a*) weak shells; (*b*) reddish-brown resin blisters on the cured shells; and (*c*) undispersed wetting agent; this is usually revealed by a number of wet sand balls about ¼ to ½ in. dia.

Strength Test.—The strength test results shown in Fig. 1 were determined by the transverse or cross-breaking strength method, where bars of cured sand/resin mixture 8 in. by 1 in. by ¼ in. were broken transversely on 3-in. centres. For the testing, a Ridsdale-Dietert green-compression machine was modified by fixing a bridge with two vertical knife-edges 3 in. apart on the bottom compression face and one knife edge centrally into the top pressure face.

To make the test-bars, the mild-steel pattern is heated to approximately 200 deg. C. and sprayed with a silicone release agent, and allowed to go cold. Whilst in the cold condition, the test-bar cavities are filled with sand-resin mixture and strickled off flush. The plate is then placed in an oven running at 350 to 500 deg. C. until the resin is cured, which should take about 5 to 7 min. It is not practical to make the test-bars starting with a hot plate, as the resin develops bonding properties before strickling can be accurately completed. The equipment is shown in Fig. 4. The cross-breaking test is useful for routine control, strength assessment of competitive materials and testing new sands. The strength of typical mixtures would range from 5 to 10 lb. and mixtures having a strength of less than 5 lb. would make weak friable shells.

Shell-making Technique

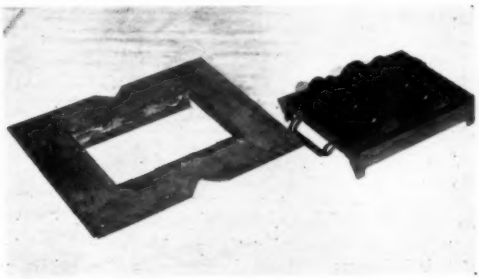
Dump buckets.—One of the arts of making good shells lies in the dump-bucket design and operation. Rough surface finish (assuming the sand to be sufficiently fine) is due to molten metal penetrating between openly packed sand grains which form the shells. It is essential if one wishes to produce first-class castings that smooth shell surfaces are due to tight packing of the sand grains and not to an excess of resin or a wax-release-agent glaze. This type of glaze is most detrimental, as, being composed of volatile matter and not refractory material, an excessive volume of gas is generated during casting. This can cause or contribute to a certain type of casting defect which is described later. At the present stage of development, the ideal dumping practice is for a depth of sand/resin mixture in the order of 10 to 14 in. to fall vertically through a distance of approximately 12 to 14 in. on to the pattern.

Good densely-packed shells can be made quite easily in a manually operated dump bucket of which the depth should be in the region of 2 ft. The dump bucket shown in Fig. 5 is used for experimental work and can accommodate a variety of patternplates simply by changing the top plate. The depth is 27 in., with trunnion centres 9 in. from the top. These measurements were the outcome of experiments on buckets ranging in depth from 15 to 36 in. The depth and the trunnion positions are the major factors which govern the following operational requirements:—(*a*) Rapid turn-over speed so mixture will have a vertical or near vertical fall with absence of horizontal slide; (*b*) good sand/resin capacity in conjuction with adequate height of fall; and (*c*) ease of turning over and back again.

Torn Shell Edges.—This defect is shown in Fig. 6 and can be caused by one or both of the following:—

(*a*) The fusing of the shell to the dump-bucket top and tearing away on pattern removal; and (*b*) fall-back due to the hanging weight of the shell edges. Early attempts to stop the shells fusing to the dump-bucket top-plate were made by having this item constructed of low-heat-conductivity materials. Hardwoods, various laminates, asbestos and glass fibre materials were tried but all produced the result shown in Fig. 6. It appeared that the better the insulator, the more the tearing.

FIG. 7.—*Ribbed patternplate and dump-bucket top plate.*



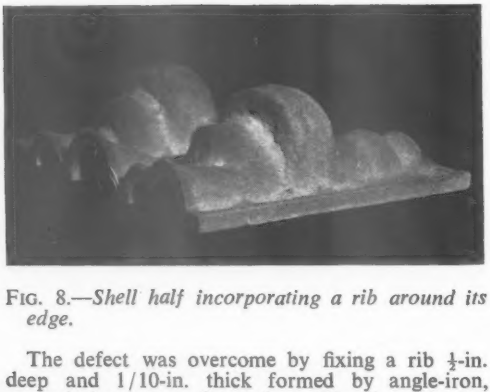


FIG. 8.—*Shell half incorporating a rib around its edge.*

The defect was overcome by fixing a rib ½-in. deep and 1/10-in. thick formed by angle-iron, around the patternplate edge. The dump-bucket top-plate was cut from steel plate ¼ in. thick and the ribbed edge of the pattern plate bedded down on to it. This resulted in line contact only and as the heat capacity and transfer of such a contact is low, the shell will not fuse on to the top plate. The rib also forms sufficient support for the hanging shell edges, and produces a flange around the shell. Fig. 7 shows a ribbed edge patternplate. The shell flange, Fig. 8, promotes rigidity and minimizes distortion during curing, ejection, assembly and casting. Should the patternplate have open-ended prints or a pouring basin for vertical casting, the rib is arranged to follow over these contours, and a method of accommodating the portions which project below the top plate is also shown in Fig. 7.

Cores

Where possible, a convenient way of producing hollow cores is on dump bucket provided that the corebox shape is such that rapid filling by gravity action is possible. With many shapes, however, gravity dumping is not fast enough and some form of blowing is required. The vertical tube blower shown in Fig. 9 was developed specially to blow the dry sand/resin shell-moulding mixture (mixture No. 1) in such a manner that an air separation of sand and resin did not occur. The air pressure (30 lb. per sq. in.) is used only as pushing medium and upon filling the tube, the air pressure is turned on and left on. By comparison with a conventional core-sand mixture, the shell-moulding mixture is a dry powder, and as such is extremely flowable under pressure. Upon opening the one-inch bore valve at the tube base, a high-velocity jet of sand/resin mixture is emitted. The speed of emission is dependent on the air pressure, and 30 lb. per sq. in. may be exceeded if necessary. If it is desired to fill from more than one point a branch pipe can be fitted. Now blowing plates have been used with this set-up, and the stream is just shut off when the box is full.

One way of permitting air escape from the box as the mixture rushes into it is to select a jet size smaller than the corebox bore. If a very fine mixture is being used, normal core vents of a grid type will often become choked. Air is prevented from running wild through the mixture and causing separation by a funnel-like reduction above the control valve which is constantly being choked by gravity action of the mixture.

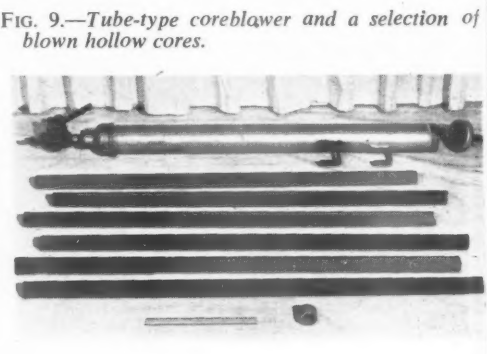
Curing Conditions

For manually-operated layouts, good shells are being produced with a patternplate temperature of 200 to 230 deg. C. and curing for about one minute in a gas oven. The requirements of a curing oven are:—(*a*) To supply even heating to the exposed shell back in such a manner that the high spots are not charred or the lower areas undercured, and (*b*) in the time required to perform (*a*), the pattern must be brought up to temperature again, so that the shell-making cycle is continuous, with no interruptions for pattern re-heating. To fulfil all these requirements, gas heating from below is best for hand-operated layouts. The advantages of this method are that the hottest gases first surge under and round the patternplate, and then with their fierceness spent they rise and circulate to cure all parts of the exposed shell evenly.

Pattern Equipment

The choice of pattern material is governed by the operating requirements of the working faces, which should be absolutely smooth and free from surface blemishes. A rigid, tightly fitting shell has to be ejected from it without the conventional initial release attained by rapping. In addition to accuracy, the process demands a much superior method of patternmaking, as the pattern operates at temperatures in the region of 200 deg. C. This renders useless materials like wax, solder, pattern varnish, etc. Ideal patterns are those machined from solid steel slabs or bars, as these are free from defects associated with cast patterns. Should steel patterns be damaged, they can be repaired by brazing. However, due to intricacy of design or cost, it may be necessary to use cast patterns, in which case cast iron or gunmetal is preferable, in most cases, to aluminium. Aluminium, being soft, is easily damaged and many aluminium cast patterns have spongy, porous areas in the region of some section junctions, in spite of lightening out.

FIG. 9.—*Tube-type coreblower and a selection of blown hollow cores.*



Ejection

The function of the ejector system is to remove the shell from the pattern without setting up high stresses. It is possible to warp a shell cured in a proper manner as much as $\frac{1}{16}$ in. per ft., or even more, as it leaves the pattern as a result of using an inadequate or uneven ejection system. The simplest and a most effective ejector pin takes the form of a long $\frac{3}{8}$ in. dia. shanked rivet having a head of $\frac{5}{8}$ to $\frac{1}{2}$ in. dia. The only work entailed in fitting is the drilling of a clearance hole as the rivet-like ejector head seats on the pattern plate. As these ejectors create a series of depressions in the shell surface, they are only suitable for grouping on the joint areas.

In certain cases, to promote good stripping, it is desirable to have ejectors operating through the prints, runner or feeder systems or even some parts of the pattern. Here, in addition to the clearance hole for the ejector stem, a seating must be counterbored in order that a flat or contoured ejector head may be flush with the surface of the shute through which it operates. As the ejector head must have a working clearance in its counter-bore, the outline of the head will be faintly visible on the casting, due to a very slight sand flash reproduction.

An open-coil, temperature-resistant compression spring holds the ejector in position, and this is retained on the ejector stem by a washer and split pin. The springs used by the Author have the following specification: $\frac{5}{8}$ in. o.d., $1\frac{1}{2}$ in. long, eight coils fully compressed by a load of 12 lb. This allows $\frac{7}{8}$ in. of ejector pin travel which is quite adequate for most purposes.

To prevent shells distorting or cracking, it is essential to have an adequate number of ejector pins and these must all operate together. The number of ejectors will be governed by the shape of the pattern or patterns and a rough guide would be 18 or more per sq. ft. In order to operate all ejectors simultaneously, some mechanical stripping aid is required. Converted straight-draw, hand moulding machines give good results, provided that no rocking occurs during ejection.

Whilst experimenting with a new pattern, it is very tempting to make shift without a proper stripper, and very often this can be the cause of disappointing results. Here the pattern is placed on a stripping block and hit with a mallet round the plate edges. It is then difficult to prevent a " see-saw " movement when the outside ejectors start working, before the centre ones, and this can cause shell distortion, jamming, breaking away of pieces and high stressing. High stressing may cause premature shell failure during pouring of the shell mould.

Contraction Allowances

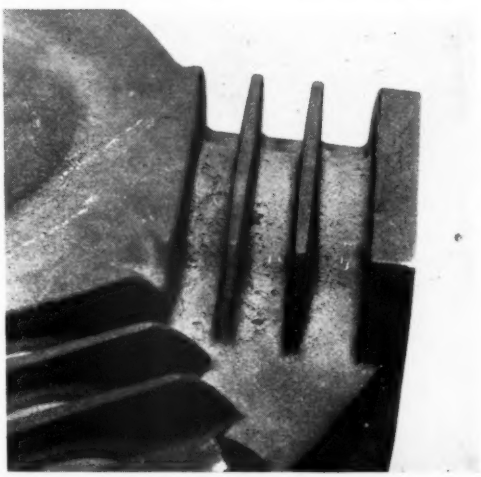
Working with machined, steel patterns mounted on a cast-iron plate, the cold shell may for most practical purposes be considered the same size as the cold pattern. The figures quoted below were determined on a camshaft which was cast vertically, without backing:—

Length of cold pattern, 17.359 in.; length of cold shells, 17.357 in.; length of cold casting, grey cast iron, 17.213 in.; length of cold casting, bronze 85/5/5/5, 17.112 in.; length of cold casting, aluminium alloy LM4 (DTD.424), 17.171 in.

Based on the above:—Contraction for cast iron = 0.0084 in. per in., or $\frac{1}{10}$ in. per ft.; contraction for LM4 = 0.0108 in. per in., or 0.13 in. per ft.; contraction for 85/5/5/5 = 0.0143 in. per in., or 0.171 in. per ft. From these results it appears that the contraction is similar to those operating for conventional sand practice.

Foundry Casting Technique

It is much easier to make good shells than it is to produce good castings. The age-old problem of



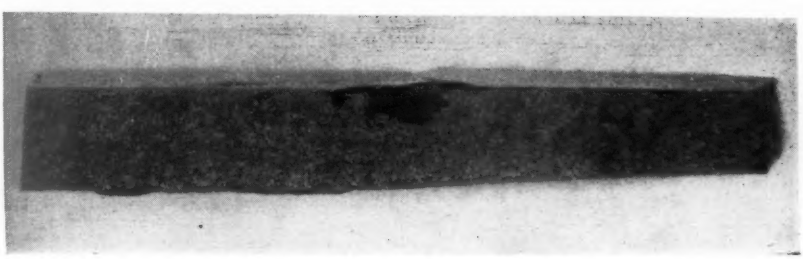


FIG. 10(*a*) (*above right*). — *General appearance of a skin-folding defect on a shell-moulded casting, and* (*b*) *fracture through a "skin-fold" or "sooty-mark,"* × 3.

metal shrinkage whilst changing from liquid to solid is still present, and shell moulding cannot reasonably be expected to eliminate gross shrinkage porosity. It is the Author's opinion that it is impossible and dangerous to attempt to generalize on runners and feeders, as each job requires individual consideration depending upon its design and service demands. As in conventional founding, the design and positioning of runners and risers in conjunction with metal-melting practice is a matter of development until a suitable technique has been established. This is a field where foundry experience is most valuable, but, as slower cooling takes place with shell moulds, it may be advisable to re-assess the effectiveness of some conventional practices. For example, it has been the Author's experience that open risers cool in air rapidly in relation to the slower cooling of the casting, so that their effective feeding efficiency is reduced and this can be corrected by enclosing the riser or using an exothermic cover.

The principles of progressive directional solidification apply as much to shell-moulded castings as any other method. As in conventional practice, pencil drop-gates have been found to work well on jobs such as vertically-poured cast-iron cylinder-liners. Much has been written about the desirability of bottom running, but this is not always the best practice, as many good side- or top-run castings are being made.

Shell Bursting

The cause and remedies for shell failure may be one or a combination of:

(*a*) *Low-strength shells.*—Check the sand/resin mixture by a strength test (mixtures left in an exposed position deteriorate rapidly over a damp week-end).

(*b*) *Excessive pouring temperature.*—It has been established that excessive pouring temperatures can cause shell failure, as metal may still be fluid whilst the shell is in an advanced stage of breakdown due to resin burnt out.

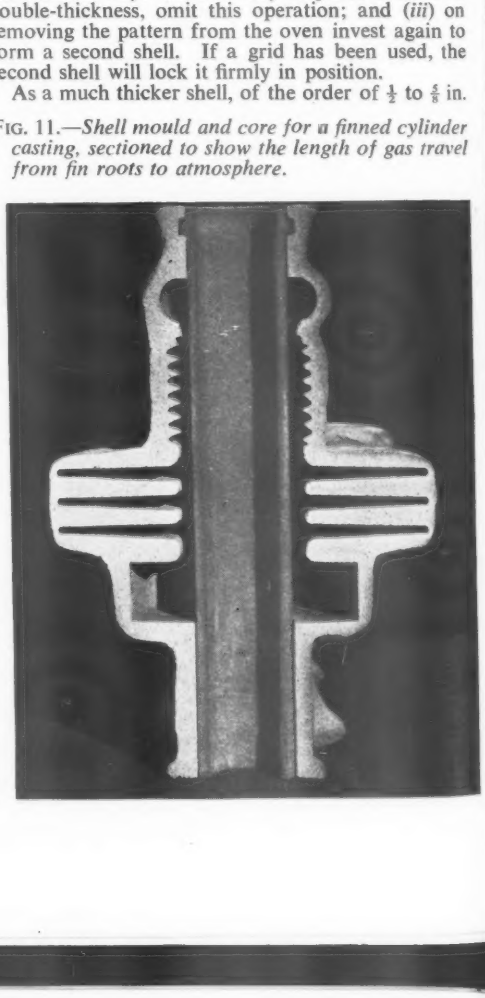
(*c*) *Heavy-section burst-outs.* — Heavy-section castings may remain liquid after the shell has been seriously weakened locally by resin burnt out. A suggested approach to this problem is to reduce the solidification time by attempting to fill the mould rapidly with cooler metal. An increase in effective ingate area may be called for, together with careful positioning. A contrasting method was employed on a heavy, cast-iron cylinder-liner to reduce the time the metal remained liquid in the shell. This liner was 24 in. long, 11 in. dia., of general section of approximately 1 in. and weighed about 200 lb., including the ring riser. It was cast vertically in unbacked shells $\frac{5}{8}$ in. thick. A ring core having a number of small pencil drop-gates introduced metal vertically from a ring gully. The positions of the drop-gates were so arranged that metal fell vertically without impinging on the side walls. The speed of pouring, governed by the number and size of drop-gates, was so slowed up that the solidification level was only a short distance behind the metal level. This also prompted excellent directional solidification. As the vertically falling streams of metal did not flow directly over the exposed shell walls, very little resin burn out occurred in the unfilled parts of the mould until contact was made with the rising metal level.

(*d*) *Stress failures.*—Shells that have suffered high stresses during ejection and assembly due to bad technique may crack during pouring. A typical trouble of this type is when two badly distorted shells are pulled together during assembly and, in the case of a vertically-cast spray, they would probably burst along the downgate. A remedy is to improve shell-making and ejection technique.

(*e*) *Sand grain expansion.*—Normal sand-expansion troubles, like scabs and rate-tails, have never been experienced by the Author, but in the case of sizable, flattish shells it would appear that sand-grain expansion contributes to the explanation of why unbacked shells crack or distort during or just after casting. At the moment there is no simple remedy which is suitable for all castings, but the following double-investment technique (with or without reinforcement) has worked satisfactorily on a number of jobs. Thus, one should (*i*) invest pattern in normal way; (*ii*) before curing push a reinforcing grid on to the "green" shell and cure in the normal way. If one only requires a shell of double-thickness, omit this operation; and (*iii*) on removing the pattern from the oven invest again to form a second shell. If a grid has been used, the second shell will lock it firmly in position.

As a much thicker shell, of the order of $\frac{1}{2}$ to $\frac{5}{8}$ in.

FIG. 11.—*Shell mould and core for a finned cylinder casting, sectioned to show the length of gas travel from fin roots to atmosphere.*



is produced, the gas given off from the resin breakdown will not get away so quickly. In order to avoid "skin-fold" or "marking" defects, it is advisable to reduce the resin content to a minimum (approximately 3½ per cent. p.-f. resin, dependent on sands and resin strength) and if necessary the thickness of the first shell. The second investment mixture should consist of a high-permeability, coarse sand with as low a resin content as possible.

Skin Folding or Marking Defects

This type of defect is shown in Figs. 10(*a*) and (*b*) and the Author's view is that it is mainly attributable to shortcomings of the shell-making mixture. A cold shell is very permeable, but upon being filled with metal, resin gases are rapidly generated. With good practice, this gas will easily escape to atmosphere without setting up a back pressure greater than that of the metal pressure. Under certain bad conditions, the gas pressure will become excessive and gas will blow into the metal. When the metal loses its fluidity the bubbles will be entrapped in various stages of collapse, and will appear upon visual examination of the casting surface apparently as "cold-shuts," "skin folds" and, finally, "sooty marks." Fig. 10(*b*) shows a fracture through a "sooty mark" which is the collapsed skin of a bubble. The following factors favour skin folding: (*a*) Too fine a sand used, with a high resin content (6 to 10 per cent.); (*b*) very thick shells; (*c*) excessive length of gas path through the shell before the gas escapes, *e.g.*, parts of the mould between deep fins on air-cooled cylinders, where the path of gas travel to atmosphere may be 2 in. or more (Fig. 11); and (*d*) badly-designed and wrongly-placed ingates.

A study of the permeability curves (Fig. 2) shows that a 50/50 Redhill grade-F and grade-H mixture has a much greater capacity for conducting gases than the all fine, grade-H mixture. The presence of the coarser sand enables a reduction in resin content to 3½ parts high strength p.-f. resin to be made. Fine sands require more resin for equal shell strengths, as compared with sands containing a proportion of coarser gradings.

Increase in permeability and decrease of resin content are the major factors in eliminating these defects. In the case of very thick shells, of the order of ⅝ in., made with fine sand, resistance is offered to escaping gases and should thick shells be deemed necessary, it is preferable to use the double-investment technique, employing two grades of sand/resin mixture.

To a much smaller extent, skin folding is influenced by ingate design and position, when it is usually confined to a local area adjacent to the ingates. Wedge-shaped ingates, which taper down sharply from the runner-bar (or downgate) to the point of entry and produce a squibbing effect, seem to be notorious for causing local marking. A better way is to make the ingate an even thickness from the runner-bar to the casting, which method will greatly reduce turbulence.

When the selection of sand/resin mixture is the basic fault, attempts to overcome the defects by adopting various types of running systems merely seem to "chase them." A probable explanation is that, although the gas bubbles may enter the casting at the same spots, the outcome of the various running systems is to push the bubbles to different parts of the casting in a like manner that conventionally-moulded castings may have blowholes and other defects that have been carried away from their point of origin.

Acknowledgments

The Author wishes to thank the Company directors for permission to release information.

Importance of Colonial Expansion

Mr. Oliver Lyttelton, the Colonial Secretary, speaking in Birmingham on May 28 at a dinner of the Birmingham and West Midlands branch of the Institute of Directors, of which he is a national vice-president, expressed his confidence in the eventual end of the present "convulsions and setbacks," in the Colonial empire, and said that in the expansion of Colonial trade and the development of new industries in the Colonial territories there lay before Britain one of the greatest opportunities of the present century.

Mr. Lyttelton said he could give a message of hope to industrialists who were thinking of trading with the Colonies or even of establishing new businesses there. It was important, however, that new industries should be of the right kind; industries which would help the main economy of the Colonial territories, for example, the manufacture of agricultural machinery. Those considering development in the Colonies could be assured of the co-operation of the Colonial governments, of assured markets for their goods, and of being able to carry on their businesses without too much interference from the United Kingdom Government. Industrialists needed confidence in the political stability of the countries in which they invested money, and he felt able to give an assurance of that future stability.

Twelfth-century Ironworks

The discovery of the site of a 12th century ironworks is recorded in the report of the 1953 excavations at Kirkstall Abbey, Leeds, published by the Thoresby Society. The report describes the finding of a layer of charcoal varying in thickness from 1 in. to 4 in. and says that in it was a great quantity of iron slag in lumps varying from the size of a pea to that of a cricket ball and larger. The charcoal layer appeared to be the sweepings of a small furnace or bloomery, which, says the report, could not have been on the site, as the clay floor was never baked. But it could not have been many yards away or the charcoal would have had time to cool.

Fortunately, the latest age of the layer can be dated stratigraphically with certainty to the second half of the 12th century. "Thus we are presented with the picture of the monks arriving at the site, bringing in iron ore for the masons' and carpenters' tools or alternatively of iron smelters on the site before the appearance of the monks. This seems less likely for ore does not occur within the immediate vicinity and a valley site is most unusual for a bloomery. There is plenty of evidence for monastic forges in the middle ages, but a 12th-century monastic bloomery is much more unusual."

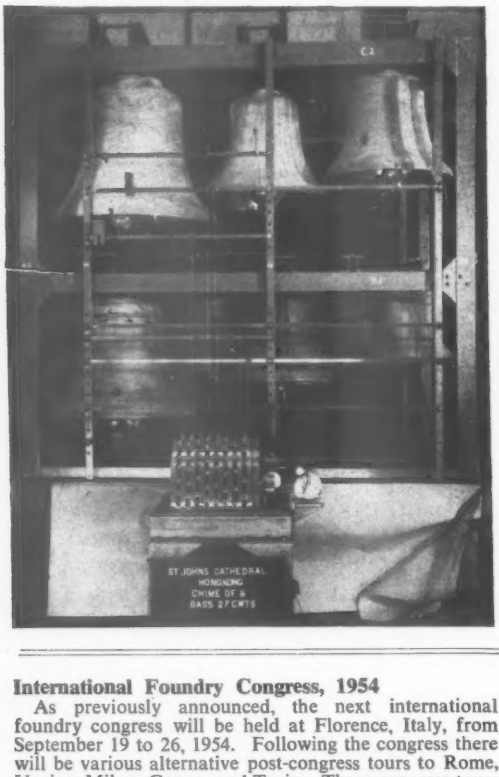
F

More Work for Croydon

Gillett & Johnston, Limited, the Croydon bellfounders, who were entrusted with the re-casting of the St. Nicholas carillon, Aberdeen, have been given the contract to extend the carillon from 37 to 48 bells. The work, which is expected to take until September, will cost over £11,000 and involve new metal to a total of 14 ton. The re-casting in 1952* cost £8,000 but for this much of the old metal was used. Bells to be furnished are Nos. 1 to 5, trebles, each of about 10-in. dia., and 28 lb. weight; Nos. 41 of 48½ in. dia. (22½ cwt.); No. 43 of 54½ in. dia.; No. 44, 58 in.; No. 45, 61½ in.; No. 46, 65 in.; and No. 47 of 70 in. dia. (over 3 ton 6 cwt.). Number 48 is the existing Bourdon bell (4½ ton). This carillon will then be the biggest in Britain; the Bournville carillon, with its Bourdon of only 3 ton, being considerably lighter, though this, too, is of four octaves. Chiming of the Aberdeen bells is to remain, as at present, on the Bourdon, but the mechanical tune-playing arrangement is to be transferred to a lower range of bells. The clavier installed in 1952 will accommodate the four-octave range.

It is interesting to note that in bellfounding, there is a modern tendency particularly in the United States not only to build electronic bell installations simulating carillons, but also to build carillons of small bells weighing a few pounds each. Whilst these installations sound satisfactory when tested at low level, when installed in a high tower their lack of resonance and range is often disappointing. Recent work (concluded last November) executed by the Croydon firm was the provision of a chime of eight bells for St. John's Cathedral at Hong Kong. These were donated by the Shanghai Banking Corporation; the tenor bell (largest), weighing 27 cwt., and the whole chime (4½ ton) are shown in the accompanying illustrations.

*See also JOURNAL, December 6, 1951, p.642; September 25, 1952, p.362; and October 2, 1952, p.384.



Chime of eight bells and—separately—the tenor bell for Hong Kong Cathedral, all of which were cast by Gillett & Johnston Limited, Croydon.

International Foundry Congress, 1954

As previously announced, the next international foundry congress will be held at Florence, Italy, from September 19 to 26, 1954. Following the congress there will be various alternative post-congress tours to Rome, Venice, Milan, Genoa, and Turin. These congress tours will include visits to works and sightseeing.

Full details of the tours are promised by the organizers at an early date, and will be circulated by the secretary of the Institute of British Foundrymen to all those who have indicated their interest in the congress. Any other members who would like to receive information are asked to send their names to the secretary immediately and information will be sent as, and when, ready. Arrangements are in hand for the participation of an organized party from this country.

Scottish Industries Exhibition

The second Scottish Industries Exhibition, to be held in Glasgow in September, will it is hoped bring a repetition of the success of their first trade fair in 1949 when, according to one official, the number of buyers was nearly twice that at this year's British Industries Fair.

Mr. R. A. Maclean, chairman of the exhibition, which is sponsored by the Scottish Council and financed by the Scottish people without Government aid, said recently that the leading concerns in almost every Scottish industry would be at the exhibition, supported by many medium and smaller firms. To finance the exhibition a guarantee fund, with a target of £100,000, was launched. Within a few months £130,000 had been subscribed and the fund closed.

Enamel Milling*

By R. W. H. Bennett, A.M.I. Mech.E.

[Slightly Abridged]

Ball milling is an increasingly important function of modern vitreous enamelling, where economic production of finely ground materials is required, and in various industries the ball mill has gradually replaced many earlier fine-grinding machines such as triple-roll machines, pan mills and edge-runner mills. This Paper first deals with the requirements of mills generally, and then with the special characteristics of enamel milling and the use of rubber-lined mills. Important items considered include factors promoting mill efficiency; pebble size and grading; frit loading and water content. Mill linings of the orthodox type are compared in relation to those produced by the Author's firm.

Ball Mill

A basic requirement of a ball mill is that the machine should be capable of producing the required product constantly and efficiently; contamination from cylinder or lining should be at a minimum. The degree of contamination permissible from a cylinder obviously varies with the industry concerned, but it follows that the greater the degree of contamination in the product, the higher the rate of wear on the cylinder or lining. The cylinder should be capable of rapid loading and discharge and must be easily cleaned. Simplicity in design should be combined with robust construction and allow for a minimum of maintenance. Power consumption should be low and first cost not so high that it cannot be recovered over a moderate period. A most important factor is the selection of a suitable material for the cylinder, in which the work has to be done.

Grinding Technique

There are two important methods of milling: (a) A high-speed mill, using a comparatively low pebble content of the charge; and (b) a slow-speed mill, using a higher pebble charge. In the high-speed mill technique, grinding is mainly by impact between pebble and shell, and with the slow-speed mill, grinding is almost entirely by attrition between pebble and pebble.

It is interesting to note that, some years ago, it was necessary to carry out some comprehensive tests on the crushing or grinding of ores to provide comparative data between the high-speed and low-speed milling techniques. Tests were carried out on mill-scale, sintered ore and magnetite, all materials of high specific gravity and very abrasive. Steel balls were used as grinding media. The high-speed mill was of all-metal construction and the slow-speed mill had a solid rubber shell. The results proved that the slow-speed milling technique adopted in the rubber mill was the more efficient. This is mentioned as additional evidence that grinding by the slow-speed technique, as employed in the vitreous-enamelling industry, is almost entirely by attrition and compression, and not—as earlier theories suggested—mainly by impact.

*Paper presented to the Southern section of the Institute of Vitreous Enamellers, Mr. B. B. Kent presiding.

Milling Variables

Important variables involved in the ball-milling of enamel frits are: Mill speed; pebble charge; pebble grading; frit charge; and water content, and consistency.

Mill speed.

The ideal speed is that at which the pebbles are all in a state of movement and in intimate contact, whilst maximum kinetic energy is produced without loss of pebble mass-pressure. Various workers have, however, established differing theories on arriving at the correct mill speed. J. W. Mellors' formula suggests:—

$$N = \frac{43.3}{\sqrt{(D-d)}}$$

where N = r.p.m.; D = internal diameter of the cylinder (in feet) and, d = mean diameter of pebble (in feet). S. W. Kendall and many others suggest that correct mill speed should be expressed as a percentage of the critical speed. Kendall bases his theories on hundreds of practical experiments in the paint and lacquer trades.

Now the critical speed is that speed at which centrifugal force acting on a particle equals the weight or gravitational force of that particle and is defined as:—

$$N = \frac{54.18}{\sqrt{R}}$$

where N = r.p.m.; R = internal radius of the cylinder (in feet). Recommended speeds vary from 55 to 65 per cent. of the critical speed. It is important to note that, if the mill speed be too high *i.e.*—near the critical speed, rapid wear occurs on the cylinder wall. In addition, the pebbles break and wear rapidly. If the speed be too low, again, rapid wear occurs on the cylinder wall due to the sliding of the charge. Grinding efficiency is low and excessive heating occurs.

Whilst the Author cannot lay claim to any prolonged practical experience of milling, he has had the advantage of seeing hundreds of mills in operation under widely differing conditions and is now convinced that, if mills are run at speeds closely approximating to those indicated in Fig. 1, a general improvement in grinding efficiency will result. In the past, many experienced millers have often gauged the correct speed of their cylinders by sound alone. Audible evidence is valuable in that

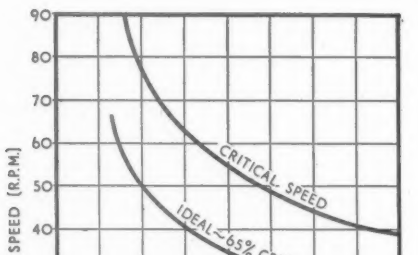


FIG. 1.—*Recommended mill speeds for rubber cylinders, the ideal being based on 65 per cent. of the critical speed.*

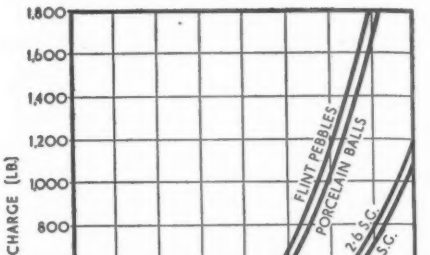


FIG. 2.—*Graphical indication of optimum loadings of flint or porcelain pebbles according to mill dimensions.*

it can indicate when mills are running very slowly; in this case a surging of the charge can be heard. On the other hand when mills are running very fast there is a noteworthy absence of noise. Between these extremes, however, there is wide room for the introduction of a more scientific approach to the ideal speed.

To attain the ideal conditions stated earlier, differing speeds will be necessary for linings having varying coefficients of friction. For a given speed, slippage of pebbles will occur earlier on a porcelain lining than on a Silex lining. Another interesting and perhaps more important comparison is between hard lining materials and soft rubber. At any given speed, a higher pebble lift during rotation is achieved in a soft rubber cylinder, because the wall yields to the weight of pebbles and they are lifted up in the indentations so formed. To overcome slippage, in the paint trades lifter bars are often installed. This method is obviously not practicable in the vitreous enamelling industry. It follows that maximum efficiencies are achieved in rubber cylinders when running at slower speeds than mills having hard linings.

The subject is obviously one on which further research has yet to be carried out, so far as rubber mills are concerned, and this is actually being done at present with a view to further increasing mill efficiency. In Fig. 1 are given mill speeds for rubber cylinders, based on internal diameters. The speeds are based on 65 per cent. of the critical speed.

Therefore, $N_1 = \frac{35.22}{\sqrt{R}}$; N_1 being ideal mill speed.

Pebble Charge

The apparent pebble charge should occupy 55 per cent. of the mill volume. Considerable reduction in grinding efficiency results as the pebble charge decreases—grinding time lengthens and final temperatures rise well above normal—this being undesirable with most vitreous enamels. Production tests in rubber cylinders have shown that if the charge is reduced to 40 per cent. of the mill volume, a reduction in overall grinding efficiency, of the order of 25 per cent. results.

Due to their higher specific gravity and consequent higher grinding efficiency, flint pebbles are still favoured for grip-coat enamels. Being natural raw material they are however prone to contaminate due to foreign inclusions. Consequently porcelain pebbles are normally used for cover-coat enamel, whites or delicate colours. Experiments have been carried out with both alumina and Steatite pebbles, each apparently giving satisfactory results. Table I shows correct cylinder loadings for flint and porcelain pebbles and Fig. 2 indicates the loadings graphically.

TABLE I.—*Correct Cylinder Loadings for Flint and Porcelain Pebbles.*

Mill Dimensions (internal) (in.)		Total Mill Volume. Cub. ft.	Flint (lb.)	Porcelain (lb.)
Dia.	Length			
8	8	0.23	12.5	11.5
12	12	0.79	42.7	39.5
18	18	2.65	144.0	132.5
24	24	6.28	342.0	314.0
30	30	12.27	666.0	612.0
36	36	21.22	1152.0	1058.0
42	42	33.68	1830.0	1681.0
48	48	50.27	2738.0	2513.0

Pebble Grading

Being satisfied that grinding is almost entirely by attrition, it follows that the smaller the pebble the greater the number of contacts doing useful work. Similarly, the higher the specific gravity of the pebble, the smaller the optimum size. Naturally the minimum pebble-size practicable is dependent on initial frit-particle size and viscosity of the charge. Considering purely frit-particle size and minimum

pebble size, Fahrenwald gives the formula:—

$$\text{Cos}\ \frac{\phi}{2} = \frac{r}{\frac{r+S}{2}}$$; where ϕ=angle of nip between pebble and frit particle and can be regarded as constant at 17 deg., r=radius of pebble and S=apparent diameter of particle.

This serves as a very useful guide but cannot be regarded as entirely conclusive. As stated, minimum pebble-size will also be dependent on the viscosity of the enamel "slip," and a "slip" of higher viscosity will necessitate larger pebbles or pebbles of higher specific gravity. Pebbles too light or too small would in effect be suspended and do no useful work. A mixture of pebble sizes in a cylinder is always desirable, this to promote movement within the pebble mass. With suitably quenched frits, which are usual to-day owing to the high standard of raw frit production, pebbles in excess of 2½ in. dia. are not normally necessary.

In view of the considerably reduced pebble wear in rubber cylinders, found to be approximately one-tenth of that with hard-lined mills, the pebble grading required to attain maximum grinding efficiency can be readily maintained. This reduction of pebble wear is due to the elimination of breakage by impact against a hard shell. Table II indicates suitable pebble grading for a given mill diameter:—

TABLE II.—*Suitable Pebble Grading.*

Mill Diameter (in.)	Pebble Diameter (in.).
12	75 per cent. 1 and 25 per cent. 1½.
24	25 per cent. 1 and 55 per cent. 1½ with 20 per cent. 2.
36	70 per cent. 1½ and 10 per cent. 2 with 20 per cent. 2½.
48	40 per cent. 1½ and 30 per cent. 2 with 30 per cent. 2½.

Frit Charge

The volume of frit charge should equal the volume of voids between the pebbles. For an apparent pebble charge of 55 per cent. of the total mill volume, the actual void volume approximates to 22 per cent. of the total mill volume. The frit charge should, therefore, be in the region of 21 to 23 lb. per cub. ft. of the mill volume, this value varying with the specific gravity of the frit.

A. Andrews, in his published work, emphasizes the necessity for maintaining constant grinding conditions. He points out that in a mill with a hard lining, it is essential to compensate for increased mill volume due to wear, stressing that, if this is not done, an enamel of quite different properties results. Table III indicates typical charges for frits of 2.4 to 2.6 specific gravity.

TABLE III.—*Frit Loading for Mills of Varying Diameter.*

Internal Mill dia. and length (in.)	Mill Volume (Cub. ft.)	Frit. (lb.).	
		S.G. 2.4	S.G. 2.6
8	0.23	4.8	5.3
12	0.79	16.5	18.1
18	2.65	55.6	60.9
24	6.28	131.8	144.2
30	12.28	253.8	282.0
36	21.22	446.0	487.0
42	33.68	707.0	774.0
48	50.27	1058.0	1158.0

Water Content

The viscosity of a charge will be governed by the water content, the nature and particle size of the frit and the mill additions. On these factors maximum milling efficiency will also be dependent. It has been established that, due to the differences in "set" of various frits, the water content for promoting maximum grinding efficiency can vary from 30 to 60 per cent. by weight. Whilst maximum grinding efficiency is always desirable, it is appreciated that the water content of the "slip" will to a great extent be governed by subsequent processing requirements. It is obvious then that on this factor the mill room must be prepared to compromise.

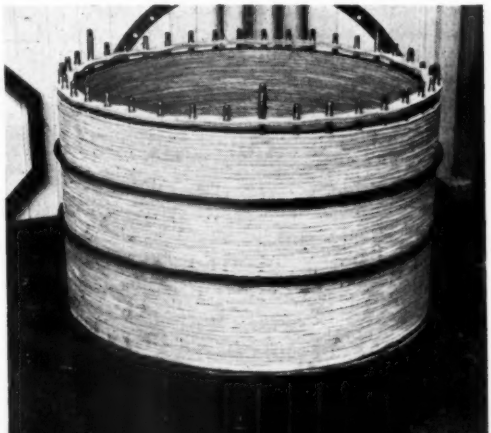
The Author regretfully observes that, even in some of the larger vitreous-enamelling organizations, milling technique is still very much by rule-of-thumb methods, and few organizations achieve maximum efficiency from their ball mills, despite the development of modern machinery and equipment. There is, naturally, a reluctance to alter technique, however slightly, lest the final enamelled product be affected. It is, however, proved that increased milling efficiency, apart from reducing milling times, also reduces contamination and temperature rise and do nothing but improve the final product.

Types of Mills

Continuous Mills

These are widely used in the cement, plaster-board and to a smaller extent in the ceramic industries. Designed for large-scale production of a single material, continuous mills are not normally suitable

FIG. 3.—*Building-up a Linatex mill from rubber rings and tie-rods.*



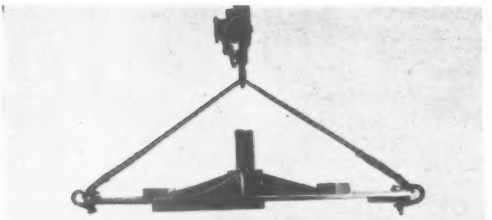


FIG. 4.—*Assembling the rubber-mill endplate and trunnion.*

for the requirements of the vitreous enamelling industry. The grinding medium varies from steel balls to cast "logs," the latter being common in the mica industries. The linings are normally of chilled iron or hardened steel.

Batch Mills

Batch mills are favoured by industries requiring small-to-medium quantities of materials, varying in colour and composition, as in the enamelling industry. Here, the grinding medium varies from ceramic material to tungsten-carbide balls.

Linings Employed in the Vitreous-enamelling Industry

Porcelain

Porcelain linings are widely used, and, when installed by skilled labour, correctly-fired porcelain blocks give a reasonable life. Metal contamination should not occur and, if the lining is maintained in good condition, the cylinder can be cleaned fairly readily.

Silex

Silex or granite lining blocks are occasionally used. A natural, hard-wearing raw material, machined or hewn into blocks, it gives a longer life than porcelain. Unmachined blocks are difficult to instal, wider cement joints being necessary, but the adoption of machined blocks increases the lining cost considerably. Using these blocks, there is a risk of contamination from foreign inclusions within the raw material. Further contamination can arise from the cement, particularly if rough-hewn blocks be used. Consequently, Silex linings are normally employed only for grip-coat enamels and rarely for white or delicate colours.

Metal

Steel or cast linings cannot be considered due to the risk of metallic contamination.

Heat-vulcanized Rubber

Very briefly, heat-vulcanized rubber is produced from raw, uncured rubber sheet to which are added varying percentages of fillers and vulcanizing ingredients, all being masticated and milled together at fairly high temperature to ensure that uniform dispersion of the ingredients is achieved. Differing physical properties are obtainable by varying the rubber mixture. Rapid vulcanization takes place during the moulding or bonding process, steam or electrical vulcanizers applying the necessary heat and pressure. High bond strength is normal to-day, as a result of adopting suitable techniques.

In view of the successful use of rubber in the majority of industries where severe abrasion is encountered, it is natural that the vitreous-enamelling industry should seriously consider the possibilities of rubber linings for ball mills. As early as 1928, American vitreous enamel manufacturers were experimenting with rubber linings. Unfortunately, heat-vulvanized, rubber-lined mills cannot be regarded altogether as successful in this field of application. Several eminent members of the Institute of Vitreous Enamellers have spoken with feeling on this lack of success, and the Author proposes briefly to analyse the reasons for failure, particularly as applied to vitreous enamels.

The normal construction of a rubber-lined cylinder is usually as follows:—

A steel or cast-iron cylinder of relatively smooth internal surface is required. Successive layers of two or more heat-vulcanized rubbers are then applied to this surface. The first layer is naturally selected for its bonding strength to a metal surface, the final layer or layers being chosen for wear resistance, coupled with adequate bond strength. It will be noted that the material has to be a compromise between two requirements, maximum wear resistance and maximum bond strength. With this method of construction, mechanical means of supporting the lining cannot conveniently be employed, consequently the success of such a lining depends entirely on the bond strength. Failure due to the rupture of this bond has been common to all industries, due to the shearing action of the charge and grinding medium.

The main drawback from the vitreous-enamelling industry's viewpoint was the considerable risk of contamination from abraded particles sheared from the surface of the heat-vulcanized rubber, irrespective of the quality of that material. When ground into the vitreous-enamel charge, these fine particles of rubber, although giving less contamination than from Silex or porcelain linings and their cements, have had disastrous effects on the applied enamels. After firing, the impurities were evident in the form of carbon specks in the finished enamel.

Mills of Rubber Construction

The Linatex ball mill is a different type of rubber-lined mill and one which is to-day achieving quite a measure of success in the enamelling industry. The rubber is prepared by a patented and strictly controlled process actually on the site of the rubber estates. Curing ingredients are ball milled and then mixed into the liquid latex. After coagulation, the material is sheeted between rolls until the desired thickness is produced. The sheets are then stored for a period of some months, during which time self-vulcanization takes place at the temperatures obtaining in the tropics. Thus no heat is applied at any time throughout the process. The resultant product is of 95 per cent. purity. Unlike some heat-vulcanized rubbers, a pure rubber retains a number of natural physical properties entirely unimpaired. It has excellent wear-resisting properties and most important of all, unlike some rubbers, there is no tendency to abrade; it is substantially non-ageing and extremely resilient. Another important characteristic is ability to be readily joined, both to itself and to metals, by a cold-cementing process, using special cements, so that a virtually homogeneous bond, rubber to rubber, can be obtained and a high bond strength to metal is attainable without the application of heat.

Construction

The main design feature of a mill of this latter type is that the cylinder consists of solid, pure-rubber rings, through which are passed rods of high-tensile steel. By its fabrication, each ring is in compression on its internal face, and by uniform tightening of the tie-rods during the building up of the cylinder, a compressive stress is applied longitudinally, a calculated stress of 9 per cent. being applied. The cylinder therefore is in compression in two planes—circumferentially and longitudinally. Rubber at a correct degree of compression is in an ideal state for resisting abrasion.

The end plates of the cylinder, also, are covered with Linatex, which is mechanically secured around its periphery between the cylinder wall and the steel end-plates. A solid rubber stopper shaped to the exact contour of the cylinder is fitted. The result is a solid-rubber cylinder, without necessitating the employment of a steel shell. Figs. 3 to 6 show the special rubber mills under construction, and also indicate the types of drives available:—

Advantages of Rubber Mills

The main advantage of the rubber-cylinder mill is the complete elimination of cylinder-wall contamination, together with considerably reduced pebble contamination. As stated earlier, pebble contamination is reduced to some 10 per cent. of that normal to be expected hard-lined cylinders. As a result, the ground product is generally acknowledged to be superior. The necessity for reducing contamination is becoming an increasingly important factor in modern enamel development.

Very long life is to be expected from the rubber mills, this obviating the tiresome necessity for periodic relinings with their accompanying disruption of production. Coupled with this factor are risks of failure of conventional lining blocks and cements due to a variety of causes mentioned.

Rubber mills have been engaged in constant production of vitreous enamels over four to five years and it was found that wear was virtually eliminated. With other mills a quite usual life was in the region of two to three years. Thus grinding conditions can be stabilized over longer periods—reducing the necessity for frequent inspections. Conventional mills (and this includes heat vulcanized rubber-lined

FIG. 5.—*Complete rubber mill, trunnion mounted.*

FIG. 6.—*Small type of rubber mill, roller mounted.*

cylinders) are very prone to early damage around the handhole. To offset this unfortunate effect, it is often recommended that stoppers, preferably of rubber, be used and that they should project into the cylinder beyond the cylinder lining, and be replaced as they wear down to the level of the lining. This is necessary with harder materials, but with rubber mills it is the practice to fabricate the stopper accurately to the contour of the cylinder so that the internal surface of the cylinder is in effect unbroken throughout, giving the ideal conditions for flow of pebbles and charge within the cylinder. Then, by careful design and a suitable material, excessive wear around the handhole is eliminated.

With some mill linings, absorption has a marked effect on specific gravity, but the rubber mill is non-absorbent and rubber cylinders can be readily cleaned without risk of frit particles being trapped in lining joints. Grinding efficiency compares favourably, but research on varying pebble charges has shown that efficiency tends to fall off a little more steeply if pebble charges fall well below the recommended optimum of 55 per cent. of the apparent volume.

Power Consumption.

By virtue of the fact that the cylinder is constructed of pure rubber (0.98 specific gravity), the weight is reduced considerably and as would be expected, the power required for rubber cylinders is lower than for hard-lined units. Consequently, the initial torque load is reduced and when conversions have been made from existing units, it is possible to instal a rubber cylinder of large capacity, whilst still maintaining the existing driving unit. Overall dimensions of rubber mills are small by comparison, therefore, greater output is attained per square foot of floor space. First cost of rubber mills is higher than others, but it can be claimed that overall cost is favourable. Noise, too, is reduced.

Conclusions and Acknowledgments

In conclusion, the Author expresses appreciation to his many friends in the vitreous enamelling industry who have co-operated in providing data on installations; also to colleagues, who have given valuable criticism during the preparation of the Paper, and to Wilkinson Rubber Linatex Limited for permission to use photographs, diagrams, etc.

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A SPECIAL SUMMER COURSE in the casting of light metals will be offered from August 23 through September 3 this year, at the Massachusetts Institute of Technology. Howard F. Taylor, Professor of Metallurgy at M.I.T., will direct the course, assisted by other members of the staff and by guest lecturers from industrial and research organizations.

Smith & Wellstood Centenary

Smith & Wellstood, Limited, makers of the "Esse" range of cookers, entertained over 1,500 employees and guests to high tea in perhaps the largest marquee ever erected in Scotland—a gigantic tent 365 ft. long and 40 ft. wide—erected on the football field near the works at Bonnybridge on Friday last. After the meal the company adjourned to the fitting shop at the works, which was converted into a theatre for the occasion. A variety entertainment, starring many celebrated B.B.C. artistes, included contributions by employees and by the newly-formed works' choir. Part of the programme was recorded by the B.B.C. as a "Workers' Playtime" programme, and will be broadcast on June 8. Dancing followed until 1 a.m.

The firm are to institute a benevolent scheme for their employees as part of their centenary celebrations, it was announced by the chairman, Mr. R. W. Fovargue. He said that although their concern was a public company it had always been run as one large family. Their success over the past century had been due, first of all, to courage. It had taken courage on the part of Mr. James Smith to start the business; other factors responsible for success were integrity in business dealings and good workmanship. Under the benevolent scheme assistance would be given to cases completely outside National Health or other schemes of the kind. It was the intention that the trustees would be drawn from the board and from the workers generally.

Referring to the founding of the business by James Smith, the chairman said that even in those days fuel efficiency was a topical subject, and Mr. Smith had based his original stove on the American covered-wagon stove, which, he found, gave more heat for less fuel than any of the heavy kitchen ranges then in use in Scotland. That aim of the maximum heat for the minimum fuel had always been before the company, and to-day, in addition to the Bonnybridge factory, which employed about 1,000 people, there was a subsidiary factory in South Africa, and cookers were made under licence in Denmark, Holland, France, Italy, and Canada.

U.K. Equipment C.S.A. Approved

It has been the custom of the British Standards Institution/Canadian Standards Association Approvals Agency to supply lists of electrically-operated equipment manufactured in the United Kingdom and approved by the Canadian Standards Association, with addresses of the makers of the equipment. As the number has increased considerably over the last twelve months, it has become impracticable for them to issue duplicated lists and the information has now been prepared in the form of a booklet, which also includes the names and addresses of the Canadian representatives.

This booklet contains the names of the manufacturers who obtained approval before March 31, 1954, and supplementary lists will be issued, at six-monthly intervals, September 1 and March 1, each year. Copies of this booklet, and, when available, supplementary lists can be obtained free of charge from the B.S.I./C.S.A. Approvals Agency, 2, Park Street, London, W.1. A considerable number of copies of the booklet are being sent to Canada, to the C.S.A., Toronto, the United Kingdom Trade Commissioners and to all provincial chief electrical inspectors, for distribution as required.

Nodular Cast Iron*

Present Position and Future Prospects as an Engineering Material, with Special Reference to Suitability for Crankshafts

By S. B. Bailey, M.Sc. (Eng.), M.I.Mech E.

(*Continued from page* 616)

SUMMARY AND CONCLUSIONS

In the seven years which have elapsed since the first British patent application for nodular cast iron was filed, progress in the industrial use of this material has been slow in the land of its origin. The reasons for this slow progress have been the high cost of the production processes which have been employed, and the unreliability of the early results. Costs could probably be greatly reduced by the substitution of basic linings for the acid linings now in general use in melting furnaces and by the development of methods for addition of magnesium to the iron without the use of expensive alloys; foundries in the United States and the U.S.S.R. appear to be making rapid progress in these directions. Combined magnesium and cerium treatment is known to give reliable results, and there now seems to be no fundamental reason why nodular cast iron should not be produced on a large scale at an economic price.

The founding and mechanical properties of nodular cast iron are such that it could invade the fields now covered by blackheart malleable iron, high-grade flake-graphite engineering cast irons, and forged and cast carbon-steels in those applications where its special properties give it a technical advantage. Before this can happen, however, the new, reliable production process will have to be proved on a large scale in British foundries, and the price will have to be very considerably reduced.

The future production of nodular cast iron in Britain will be limited by competition for the high-grade low-phosphorus ores which are essential for the production of tough cast irons and steels. A new, cheap method for de-phosphorizing iron in the cupola would be of very great value.

The better founding properties of nodular cast iron may give it a decisive advantage over steel in the mass production of castings in shell moulds. This has already been demonstrated in the United States, where very large nnmbers of nodular-cast-iron automobile-crankshafts are now being made. Their fatigue strength appears to be adequate for this application, provided high power : weight ratios are not required.

Acknowledgments

The Author is indebted to the secretary of the Department of Scientific and Industrial Research for permission to publish this Paper, and also to the director and staff of the British Cast Iron Research Association as well as to his colleagues in the Department of Scientific and Industrial Research for much advice in the metallurgical field. However, the opinions expressed in the Paper are those of the Author, and are not necessarily shared either by the Department or by the British Cast Iron Research Association.

The Author would also like to thank the directors of various other research organizations mentioned in the references in Appendix VI for their permission to quote results from confidential research reports issued by them but not freely available to engineers in general.

He would further like to acknowledge assistance given by the following organizations: the British Cast Iron Research Association, for producing experimental castings and machined bars for surface hardening; the British Iron and Steel Research Association, for the oxy/coal-gas flame hardening of nodular-cast-iron bars; the Flame Hardeners, Limited, Sheffield, for flame hardening and induction hardening of nodular-cast-iron gears and bars.

APPENDIX I

Sources of Information

Wrought Steels. The source of data relating to wrought steels included in Fig. 6, 10, and 13 is B.S. 971 (British Standards Institution 1950) and in Fig. 12 is Gough, Pollard and Clenshaw (1951).

Cast Steels. For the data relating to cast steels given in Fig. 6, 10, and 13 the sources are the Steel Founders' Society of America (1950) and the American Foundrymen's Association (1944).

The curves for alloy steels relate to manganese/molybdenum and nickel/chrome/molybdenum steels in the quenched and tempered condition. The curves for carbon steels apply to material in the normalized condition, except for steels with carbon contents greater than 0.5 per cent., which are shown in the fully annnealed state.

The source of the data included in Fig. 12 and

* Abstracted from a Paper presented at a general meeting of the Institution of Mechanical Engineers in London, arranged in conjunction with the automobile division and the applied mechanics group. The Author is on the staff of Intelligence Division, London Headquarters, Department of Scientific and Industrial Research.

APPENDIX II, TABLE II.—*Particulars of Wöhler-fatigue-test Specimens.*

Material.	Ultimate tensile-strength, tons per sq. in.	Reverse-bending fatigue-strength, tons per sq. in.		Fatique-strength reduction factor.	Groove dimensions.				Theoretical stress concentration factor.	
		Plain.	Notched.		Angle, deg.	Root radius, in.	Root dia., in.	Depth, in.	Neuber.	Gough.
Wrought carbon-steel ..	34.1	22.2	13.6	1.63	55	0.00020	0.300	0.020	21	18.0
Wrought alloy steel	42.0	21.5	11.6	1.85	55	0.00020	0.300	0.020	21	18.0
	46.8	28.8	19.6	1.47	55	0.00040	0.300	0.020	15	13.0
	48.7	27.8	14.0	1.99	55	0.00035	0.300	0.020	16	13.8
	58.0	35.0	17.4	2.01	55	0.00080	0.300	0.020	11	9.5
	58.1	33.0	16.0	2.06	55	0.00085	0.300	0.020	11	9.2
	80.5	42.8	17.6	2.43	55	0.015	0.300	0.020	2.4	7.2
Cast alloy-steel	65	19.5	13.0	1.50	55	0.0086	0.300	0.0375	3.1	4.5
	75	22.0	14.5	1.52	55	0.0086	0.300	0.0375	3.1	4.5
	82	23.0	15.0	1.53	55	0.0086	0.300	0.0375	3.1	4.5
	85	23.5	16.0	1.47	55	0.0086	0.300	0.0375	3.1	4.5
Flake-graphite grey cast iron	23	11.0	7.0	1.57	55	0.0086	0.300	0.0375	3.1	4.5
	22	8.0	8.0	1.00	55	0.0086	0.300	0.0375	3.1	4.5
	26	12.0	11.0	1.09	55	0.0086	0.300	0.0375	3.1	4.5
	24	10.0	10.0	1.00	55	0.0086	0.300	0.0375	3.1	4.5
	25	10.5	10.5	1.00	55	0.0086	0.300	0.0375	3.1	4.5
	20.8	9.0	7.5	1.20	45	0.010	0.331	0.071	3.1	5.5
	30.3	11.5	10.5	1.09	45	0.010	0.331	0.071	3.1	5.5
Graphitic cast steel	50.0	16.0	9.0	1.78	55	0.0086	0.300	0.0375	3.1	4.5
Nodular cast iron (heat-treated)	23.1	12.0	10.5	1.14	45	0.010	0.301	0.086	3.1	6.0
	30.7	14.5	8.5	1.70	45	0.010	0.301	0.086	3.1	6.0
	36.5	15.0	8.5	1.77	45	0.010	0.301	0.086	3.1	6.0
	38.8	16.0	8.5	1.88	45	0.010	0.301	0.086	3.1	6.0
	21.0	11.0	7.5	1.47	45	0.010	0.417	0.142	3.5	7.4
	23.0	11.5	9.0	1.28	45	0.010	0.417	0.142	3.5	7.4
	25.8	13.0	8.0	1.63	45	0.010	0.417	0.142	3.5	7.4
	26.9	13.5	8.5	1.59	45	0.010	0.417	0.142	3.5	7.4
	30.6	12.5	7.5	1.67	45	0.010	0.417	0.142	3.5	7.4
	32.3	14.0	9.5	1.47	45	0.010	0.417	0.142	3.5	7.4
	34.4	13.5	7.5	1.80	45	0.010	0.417	0.142	3.5	7.4
	35 0	14.5	8.0	1.81	45	0.010	0.417	0.142	3.5	7.4
	37.8	15.5	9.5	1.63	45	0.010	0.417	0.142	3.5	7.4
Nodular cast iron (as-cast) ..	40.0	19.0	11.0	1.73	45	0.010	0.301	0.086	3.1	6.0
	43.0	18.5	10.5	1.76	45	0.010	0.301	0.086	3.1	6.0
	45.7	19.0	13.0	1.46	45	0.010	0.301	0.086	3.1	6.0
	38.9	19.0	10.0	1.90	45	0.010	0.417	0.142	3.5	7.4
	39.8	17.5	9.5	1.84	45	0.010	0.417	0.142	3.5	7.4
	40.5	18.5	10.5	1.76	45	0.010	0.417	0.142	3.5	7.4
	42.7	17.0	8.0	2.13	45	0.010	0.417	0.142	3.5	7.4
	48.0	18.0	11.5	1.57	45	0.010	0.417	0.142	3.5	7.4
Wrought alloy-steel	64.8	37.8	16.8	2.25	Radial hole 0.05 in. dia. in hollow shaft 0.50 in. o.d. by 0.35 in. i.d.				3.0	

relating to cast steels is Love (1951). The curve relates to nickel/chrome/molybdenum steels in the quenched and tempered condition.

Nodular Cast Irons. The sources of information relating to nodular cast irons are Grant (1950), Morrogh (1952), and Palmer and Gilbert (1953). These are all so-called "unalloyed" nodular cast irons, containing up to 3½ per cent. nickel.

Grey Cast Irons. For flake-graphite grey cast irons the sources of information are Gough and Pollard (1936-37) and Love (1950).

Malleable Cast Irons. Product Engineering (1942) is the course of data on malleable cast irons. The curves apply to blackheart malleable irons.

APPENDIX III

Materials for Gas-turbine Compressor Casings

*RR.*50 *and RR.*250. These are aluminium casting alloys. The first contains 0.1 per cent. copper, 0.1 per cent. magnesium, 2.5 per cent. silicon, 1.0 per cent. iron, 0.9 per cent. nickel, and 0.2 per cent. titanium; the second, 5.0 per cent. copper, 0.25 per cent. manganese, 1.0 per cent. nickel, 0.2 per cent. titanium, 0.25 per cent. cobalt, and 0.25 per cent. antimony. The data from which curves (*f*) and (*a*) in Fig. 15 and 16 were plotted were taken from the literature (High Duty Alloys 1953), and apply to material soaked for 100 hours at the test temperature.

*ZRE*1 *and ZT*1. These are magnesium casting alloys. The first contains 0.6 per cent. zirconium, 2.2 per cent. zinc, and 2.7 per cent. cerium *mischmetall*; the second, 0.7 per cent. zirconium, 2.2 per cent. zinc, and 3.0 per cent. thorium. The data from which curves (*e*) and (*b*) in Fig. 15 and 16 were plotted were taken from the literature (Magnesium Elektron 1953), and apply to a 1-hour soak at the test temperature.

Nodular Cast Iron. This is an as-cast material, pearlitic, made by the magnesium/nickel process. It contains 1.12 per cent. nickel and 0.5 per cent. manganese. The curves (*g*) in Fig. 15 and 16 are reproduced from Saunders and Sinnott (1953).

0.17 *per cent. Carbon Steel.* This is an ordinary low-carbon steel, widely used for fabricated components. The curves (*d*) in Fig. 15 and 16 are reproduced from Tapsell and Clenshaw (1927, Report No. 1).

0.53 *per cent. Cast Carbon Steel.* This is a medium-carbon steel which was at one time speci-

APPENDIX IV, TABLE III.—*Reversed-bending Fatigue-strength of Crankshafts.*

Material.	Ultimate tensile-strength, tons per sq. in.	Pin dia. (*d*), in.	Web thickness (*b*) in.	Pin-to-web-fillet radius (*r*), in.	*r*/*d*	*r*/*b*	Nominal fatigue-strength, tons per sq. in.
Flake-graphite cast irons:							
Low-alloy inoculated iron	22	4.00	1.500	0.250	0.063	0.167	3.75
Chrome/molybdenum alloy iron	21	4.00	1.500	0.250	0.063	0.167	3.40
Acicular iron	24	4.00	1.500	0.250	0.063	0.167	4.20
Low-carbon, alloy cast iron (or graphitic cast steel)	36	4.00	1.500	0.250	0.063	0.167	5.8
Magnesium-treated nodular cast iron:							
As-cast	51	4.00	1.500	0.250	0.063	0.167	5.0
Quenched and tempered	48	4.00	1.500	0.250	0.063	0.167	4.7
Cast alloy-steels:							
0.5/1.0/0.2 per cent. Ni/Cr/Mo steel	65	4.00	1.500	0.250	0.063	0.167	5.5
0.5/1.0/0.2 per cent. Ni/Cr/Mo steel	75	4.00	1.500	0.250	0.063	0.167	6.3
1.9/0.9/0.3 per cent. Ni/Cr/Mo steel	82	4.00	1.500	0.250	0.063	0.167	5.2
1.9/0.9/0.3 per cent. Ni/Cr/Mo steel	85	4.00	1.500	0.250	0.063	0.167	5.2
Forged 0.5 per cent. carbon steel	47	2.68	0.868	0.157	0.059	0.181	8.9
Forged alloy steels:							
3.7/0.85 per cent. Ni/Cr steel	58.5	2.68	0.868	0.157	0.059	0.181	10.3
2.3/0.37 per cent. Ni/Cr steel	67.8	2.50	0.843	0.156	0.063	0.185	8.9
3.4/0.9/0.5 per cent. Ni/Cr/Mo steel	69.3	1.97	0.846	0.138	0.070	0.163	11.0

fied for marine engineering castings. The curves (*c*) in Fig. 15 and 16 are reproduced from Tapsell and Clenshaw (1927, Report No. 2).

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APPENDIX V. TABLE IV.—*Notched Fatigue-strengths in Reversed Torsion.*

Material (*a*).	Test piece dia. (*b*), in.	Diameter of diametrical hole (*c*), in.	Ultimate tensile-strength (*d*), tons per sq. in.	Notched torsion fatigue-strength (*e*), tons per sq. in.	*e*/*d* × 100, per cent.	Source of data.
Wrought alloy steels	0.500	0.050	64.8	11.7	18	Gough, Pollard, and Clenshaw (1951)
	0.708	0.059	60.3	11.1	18	Cornelius (1940)
	0.708	0.059	82.5	13.7	17	" "
	0.708	0.059	62.4	12.0	19	" "
	0.708	0.059	82.5	14.0	17	" "
Graphitic cast steels	0.708	0.059	46.3	8.8	19	" "
	0.708	0.059	41.3	6.1	15	" "
Malleable cast irons	0.708	0.059	20.3	5.4	27	" "
	0.708	0.059	19.4	6.0	31	" "
Flake-graphite cast irons	0.400	0.040	9.9	3.6	36	Collins and Smith (1942)
	0.400	0.040	20.5	6.4	31	" " "
	0.400	0.040	23.9	7.1	30	" " "

Nodular Cast Iron

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Hostel for Rheumatic Sufferers

The pioneer hostel for rheumatic sufferers at Bracken Hill House, Northwood (Middx), established by B.R.A. Homes, Limited, and sponsored by the British Rheumatic Association, was officially opened last month by Miss Patricia Hornsby-Smith, M.P., Parliamentary Secretary to the Minister of Health.

The hostel is planned as a service to industry, but can be supported by tax-free welfare funds. Trade and professional associations of firms are taking up £500 nominations for beds or investing £500 in 3 per cent. loan stock. This guarantees their medically suitable nominees accommodation without delay.

Personal

COUNCILLOR G. E. HIGGS, chief inspector in the foundry at John Harper & Company, Limited, Willenhall, was unanimously elected chairman of Wednesfield Urban Council on May 24.

MR. R. RAY, of Sheffield, has received a presentation from the Midland section of the Coke Oven Managers' Association to mark his retirement from active service with the Woodall-Duckham Construction Company, Limited. He is a founder member and a past-president of the Association.

WORKS MANAGER and a director of the Steel Nut & Joseph Hampton, Limited, Darlaston, Councillor BERNARD GARMAN, a leading metallurgist, was installed as Sheriff of Lichfield on May 26. Mr. Garman has lived in Lichfield since 1946 and has been a member of the city Council since 1949.

MR. WILLIAM CHARLES BELL, a director of Stewarts and Lloyds, Limited, and managing director of the company's iron and steel production, has been awarded the medal of the American Iron and Steel Institute for his paper, "A review of European operating and technical practices." He is the first person outside the United States to be awarded the medal.

MR. R. G. HULL, manager of Northern Aluminium Company's Manchester sales office, retired on June 1. He had been in the company's employ since 1927, and last year was presented with an aluminium watch in recognition of his twenty-five years' service. Mr. Hull has been succeeded by MR. D. A. CORBETT-THOMPSON, who was formerly on the staff of the company's London sales office.

MR. C. F. HURST and MR. L. HALPIN, directors of Samuel Osborn & Company, Limited, Clyde Steel Works, Wicker, Sheffield, have returned from a visit to Israel, where the firm has started production in a new engineers' tool factory at Tel-Aviv. MR. ELIAHA ELATH, the Israel Ambassador, visited Sheffield on May 24, and toured the Clyde steelworks of Samuel Osborn and their Mushet Works.

DEAN ADRIEN POULIOT, Dean of the Faculty of Applied Science at Laval University, Quebec, is visiting the U.K. for six weeks until the end of June, under the auspices of the British Council, to study the arrangements for advanced technical training in British universities and engineering firms, and to visit research establishments. Dean Pouliot, who has held his present position since 1940, is president of the Canadian Mathematical Congress, and has held high office in a number of Canadian engineering and other scientific organizations.

MR. M. A. FIENNES, managing director of Davy & United Engineering Company, Limited, Park Iron Works, Sheffield, has returned from a visit to the United States, where he has seen two associate companies at Pittsbury and Worcester, Massachusetts. He also visited the United Steel Corporation's plant at Trentham, where strip steel tubes and bars are made. He considers that the Sheffield mills hold their own in comparison in production, quality and machinery. Also returned from a visit to the U.S. is MR. ARTHUR VILLENEUVE NICHOLLE, managing director of the Sheepbridge Engineering Company, Limited, of Chesterfield, Derbyshire.

TRADING with Cuba for the first time, the English Steel Corporation, Limited, Sheffield, have secured orders worth £11,000 for medium forgings, and a repeat order worth £8,000 has been received.

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FS/14

News in Brief

SCHEDULED for Wednesday of this week was a feature programme to be televised from the National Physical Laboratory, Teddington.

SEYMOUR'S CASTWELL FOUNDRY, LIMITED, Litchurch Lane, Derby, has leased a site at Raynesway for the erection of a new foundry.

"STEEL RIDE," a film of the manufacture of railway materials at the Rotherham works of Steel, Peech & Tozer, is being shown at Odeon cinemas in Rotherham during this week.

AN "OPEN DAY" was held at Heanor Technical College, Heanor, on May 29, when laboratories and workshops were open to visitors interested in the facilities for technical education in the district.

THE Federation of Light Metal Smelters announces that its members' average selling prices, per ton (to the nearest 10s.), for the following alloys during April have been calculated as follow:—LM1, £143 10s.; LM2, £154; LM4, £160; LM6, £183.

IT IS REGRETTED that, on page 561 of the JOURNAL of May 13, 1954, in the first numbered sub-paragraph, the word "not" was omitted. This completely reverses the sense of that paragraph, of course. Apologies are tendered to readers who were confused.

THE FIRST 700 TONS of a 2,000-ton refractories export order for the Arctic Circle have left the Sheffield works of Chambers Bros., ganister manufacturers. The order is for "47" Monolith ladle linings for ladles of up to 100 tons capacity for a steelworks in northern Sweden.

AITON AFRICA (PROPRIETARY), LIMITED, of Johannesburg, a subsidiary of Aiton & Company, Limited, pipe engineers, of Stores Road, Derby, are to build a new factory at Port Elizabeth, South Africa. When in production the chief output will be high- and low-pressure steel pipework and accessories.

MR. DUNCAN SANDYS, Minister of Supply, who was to have opened the fourth national Mechanical Handling Exhibition and Convention, is going to America for talks on weapon research and development. The exhibition will, therefore, be opened by Mr. A. R. W. LOW, M.P., Parliamentary Secretary to the Ministry of Supply.

TO MARK his 21 years' service with the Steel Breaking & Dismantling Company, Limited, of Chesterfield, Mr. Frank Wilfred Davison, who has charge of the non-ferrous stores and metal sorting, was presented with a wristlet watch. The presentation was made by Mr. A. O. Edwards, director and chairman of the company.

TAYLOR BROS. & COMPANY, LIMITED, of Trafford Park, Manchester, a member of the English Steel Corporation, celebrates the centenary of its foundation this year. It was founded in Leeds in 1854 by Mr. George Taylor, great-grandfather of Mr. R. G. H. Taylor, the present managing director. His two brothers were associated with him.

A LARGE BELL for the church at Munxar, Malta, was cast in the foundry of John Taylor & Company, of Loughborough, at 3.30 p.m. on May 25. At the same time a service of blessing was held in the church at Malta, where the authorities had asked the Loughborough firm to inform them of the exact time of casting so that the special service could be held.

Now on its way to Clyde shipbreakers is the Grand Harbour of Malta. Three Dutch tugs are taking this remaining half of the giant Singapore floating dock back to Britain after 25 years. The dock should reach the Clyde about the end of June. The dock was scuttled by the British after the fall of Singapore, raised by the Japanese, and sunk later by American bombers.

TO MARK the centenary of the birth of Sir Charles Parsons, the inventor of the steam turbine, a "Science Survey" talk about the man and his work will be given by Sir Claude Gibb, chairman and managing director of C. A. Parsons & Company, Limited, Newcastle-upon-Tyne, on June 10 in the B.B.C. Home Service. The talk will be repeated on the following Saturday morning.

MR. R. T. REDFERN, managing director, of the Bryan Donkin Company Limited, Chesterfield, is on a business trip to Canada. He is to attend the Canadian Gas Association's annual convention at Banff, Alberta, which will be held from June 20-24. The chief matter for discussion will be the projected pipe-line to carry natural gas a distance of 2,500 miles, which will be one of the largest in the world.

DR. A. PARKER, director of fuel research at the Department of Scientific and Industrial Research, addressed the Midland section of the Coke Oven Managers' Association at Sheffield. He spoke on national fuel and energy resources and their utilization. He estimated that there was enough coal in the world to last another 2,000 years, but thought that that in Britain would last only another 200 years.

ON SATURDAY, May 29, an "open day" was held at the Brush Electrical Engineering Company, Limited, Loughborough, when visitors were able to tour the works, which covers 35 acres, and also to see a complete range of the company's products. The staff of the personnel department were available to answer any questions on employment and apprenticeships. The first "open day" was held four years ago when over 7,000 visitors made a tour of the works.

AT A MEETING of Scunthorpe and District Industrial Accident Prevention Council, the district Inspector of Factories was asked: "Is there any regulation which can be put into force to prevent a man going to work wearing a pair of sandshoes instead of proper protective footwear?" The Inspector replied that action could only be taken if it could be proved that the man intended to injure himself wilfully, and he referred to a case recently of a boy found wearing sandshoes in an iron foundry.

THREE STAFF MEMBERS of William Jessop & Sons, Limited, steel manufacturers, of Brightside, Sheffield, with a total service between them of 127 years, are retiring. They are Mr. Herbert C. Stevens, heavy and light forges manager, who has been with the firm for 52 years, and was awarded the M.B.E. for outstanding work on armaments during the war; Mr. Edmund B. O. Hogg, the firm's chief draughtsman, who has been with the firm 41 years; and Mr. William E. Parr, foreman coremaker, who is retiring after 34 years with the firm.

B.S.A. TOOLS, LIMITED, announce the formation of a new company, Precision Alloy Castings (Birmingham), Limited, for the development and manufacture of precision, alloy-steel castings for jigs, tools, dies and similar applications. Five of the directors are also on the Board of B.S.A. Tools—Mr. H. J. S.

(*Continued on page* 652)

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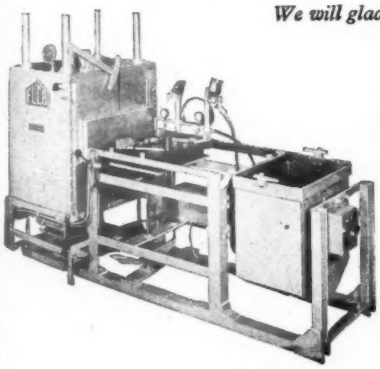

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236/51

News in Brief

(*Continued from page* 650)

Moyses, chairman; Sir Bernard Docker; Sir Patrick Hannon; Mr. W. Ogilvie; and Mr. H. P. Potts (managing). The others are Mr. K. J. B. Wolfe and Mr. S. A. Roberts. The headquarters of the company will be at Macadown Lane, Kitts Green.

AT THE THORNCLIFFE WORKS of Newton, Chambers & Company Limited, the trading hours of a mart for the selling and buying of employees' secondhand goods have been extended. The mart is held near the Barnsley Road entrance to the works. It deals in secondhand articles that are in reasonable condition and not perishable, and charges two shillings in the pound to cover administrative costs. The mart has operated for two years and the hours are now extended because of its popularity. Many thousands of articles have changed hands during that time.

AT the British Electrical Power Convention exhibition, June 14-18, at Devonshire Park, Eastbourne, Henry Wiggin & Company, Limited, on stand 48, will have available technical publications giving complete data on the wide range of high-nickel alloys which are supplied in wrought form to the electrical industry. Foremost amongst these are the Brightray alloys, a series of resistance materials for most types of electrical resistance heating up to 1,150 deg. C. The firm has recently introduced two new grades of commercially "pure" nickel known as HPA and HPB nickel.

THE NEED for small manufacturers as well as large firms to introduce management training schemes to solve "the problem of succession" was stressed by Mr. J. Ivan Yates when he was elected president of the Birmingham Chamber of Commerce on May 24. Mr. Yates is a director of Radiation, Limited, and a member of the Engineering and Allied Employers' Association. An Oxford graduate, he is a Governor of Birmingham University. Mr. J. E. Belliss, managing director of Belliss & Morcom, Limited, was elected a vice-president of the Chamber, and Councillor G. Philip Achurch, hon. treasurer.

RUSTON & HORNSBY, LIMITED, engineers and founders, Lincoln, have opened a new £32,000 sports ground on the Newark Road. The opening ceremony was performed by Mr. Norman Yardley, Yorkshire County Cricket Club captain and former England "Test" cricket captain. Mr. W. J. Ruston, chairman of the company, said the firm had about 6,600 employees in Lincoln and Grantham. The membership of the sports association, which was open to families, was 4,000, and he appealed for even more support. The ground occupies 22 acres, with cricket and football pitches, bowling greens, tennis courts, and a children's corner.

THE MILLOM IRON AND STEEL COMPANY, LIMITED, have guaranteed the expense of the renovation of the monument to John Wilkinson, the ironmaster who built the first iron boat. The monument stands in the village of Lindale-in-Cartmel, two miles from Grange-over-Sands. A plaque depicting Wilkinson's head and with an inscription describing his work has been added to the monument. This plaque was found lying in the works of Vickers-Armstrong, Limited, and was returned to Lindale. The Parish Council, who are responsible for the upkeep of the obelisk, have asked the Institute of British Foundrymen and the Newcomen Society if they can help with this.

THE NEW "Queen Anne" blast-furnace at the Scunthorpe steelworks of the Appleby Frodingham Steel Company, Limited, produced over 1,000 tons of pig-iron in 24 hours on two successive days in the week ending May 22. This is thought to be a world record for pig-iron production. The new furnace was blown-in on March 1. The works produced 82,200 tons of iron in the four weeks ending May 15. The "Queen Victoria" blast furnace at the same works, a branch of the United Steel Companies, Limited, will be lit on July 29 by Sir Archibald Forbes, chairman of the Iron and Steel Board. It will be Europe's biggest blast furnace, and is part of United Steel's "Seraphim" project costing £15,000,000.

A BIRMINGHAM AND WEST MIDLANDS branch of the Science Technologists' Association has been formed. Membership will be open to technical assistants employed in laboratories, whether research, industrial or teaching. Formed in 1948, the parent association now has about 1,000 members. It is hoped that by the end of this year it will be formed into an institute which will give it the right to conduct examinations and award diplomas in science technology. Professor A. C. Frazer, Professor of Pharmacology in the Medical School of Birmingham University, said it was infinitely better to be a good technician than a second-rate graduate, and people should decide early for which field they were better fitted. Officers elected were: *chairman,* Mr. J. A. Edwards; *secretary,* Mr. G. A. Rowe; *treasurer,* Mr. S. W. J. Clarke.

THE NEW FACTORY of Brook Motors, Limited, electrical engineers, Huddersfield, was officially opened at Barugh Green, near Barnsley, on May 28, by Sir John Keeling. As he pressed a button, a hooter sounded and the 500,000th electric motor produced at the factory, which has been in operation for a year, came off the production line. The factory "floats" on the ground on a number of concrete rafts to counteract possible subsidence due to coal mining. The 450 employees now working there will ultimately be increased to 1,000. Mr. John L. Brook, vice-chairman, mentioned the difficulty of finding suitable industrial building land in an area honeycombed with mine-workings. At the luncheon following the opening ceremony, the chairman, Mr. Frank V. Brook, described the profit-sharing scheme as being the driving force behind the firm. It had paid handsome dividends, not just from the financial standpoint.

Obituary

MR. A. J. STURGEON, managing director of Foster Electrical Supplies, Limited, and a director of Foster Transformers, Limited, died on May 26. He was 66 years of age.

THE DEATH was announced on May 25 of MR. REGINALD ASLIN, service manager of the Rover Company, Limited, Solihull. He was 58, and had been ill for about four months.

MR. WILLIAM HOLLENHEAD DAVIS, chairman of W. H. Davis and Sons (W.), Limited, general engineers, railway wagon builders, and repairers, of Langwith Junction, has died at the age of 76. The firm also control the Derwent Foundry and Engineering Works, at Whatstandwell, Derbyshire.

MR. G. T. MORRIS, who was Midland representative for the Foundry Supplies division of Harborough Construction Company, Limited, died at his home at Handsworth, Birmingham, on May 28. He had been a member of the Institute of British Foundrymen since 1941 and was well respected in foundry circles.

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Raw Material Markets

Iron and Steel

Increased prices for a number of iron and steel products came into effect on Monday. The price increases average just under 2 per cent. and range in the main from 15s. a ton for pig-iron and heavy steel products down to 2s. 6d. a ton on the lighter products. There are higher prices for a few products, and no change has been made in the prices of others. At the time of the increase in rail freights on March 1, it will be recalled, the Iron and Steel Board stated that no increases in steel prices were then being made on account of higher rail freights, but that all costs would be kept under review and such adjustments in prices as might be necessary would be made from time to time. The latest advances in iron and steel prices had been made necessary by the increase in coal and coke prices which came into force on May 3 and by recent wage increases.

The price alterations are embodied in the price list on page 32.

The Iron and Steel Board also announces that a new tinplate schedule has been introduced to reflect the economies in the production by the strip mills of bulk quantities of standard products. The result is a slight reduction in the average prices to the consumer of the strip-mill tinplate, which now represents about two-thirds of the total production. While hand-mill prices have, in general, been increased, the new price schedule will still leave the hand-mill product cheaper than that of the strip mill for small quantities and special requirements.

Although outputs of pig-iron continue at record levels, the foundries are not benefiting to any appreciable extent by the increased supplies. Apart from high-phosphorus pig-iron, which generally is coming forward in sufficient quantities to fulfil existing commitments for castings at the light, jobbing, and textile foundries, other grades remain tight and inadequate, especially the low- and medium-phosphorus irons and hematite used by the engineering and speciality foundries.

Producers of high-phosphorus iron can satisfy current demands fairly comfortably, and they are now clearing off some arrears of orders which were accumulated in the earlier part of the year. At that time a revival in trade for light castings appeared imminent, but this has not been sustained and the foundries are again content to utilize existing stocks of iron. In some instances, orders on hand for pig-iron have either been reduced in quantity or cancelled. It is no doubt because of the lack of forward bookings and for economic reasons that there is little tendency on the part of the foundries to carry large stocks, although there is every possibility of an increase in price.

The light foundries are receiving a fair number of orders for builders' castings, but the demand for castings for domestic equipment has declined. Orders for castings for the defence programme are not now being placed on as large a scale as formerly. Some of the jobbing foundries are better placed than others, depending on the kind of casting supplied and the state of prosperity of the trades for which they cater.

The engineering and speciality foundries are eager to book larger tonnages of the low- and medium-phosphorus irons and hematite. The former is in heavy demand, much larger tonnages being called for than are at present available, and hematite makers are also unable to satisfy fully present requirements. There are no stocks of these grades at either the furnaces or the foundries, and any interference in production leads to difficulty at the foundries. They are fairly well occupied, good support being forthcoming from the motor and allied trades, machine-tool and heavy electrical equipment makers, and other busy home trades. There is a good call for the better and heavier grades of cast-iron scrap. Good supplies are available of medium and light scrap.

Non-ferrous Metals

The undertone on the market is decidedly firm. Without exception gains were registered in the fairly active dealing that took place last week and there is no sign at the moment of a serious break in values; on present appearances the outlook is set fair for this year. Outside the Metal Exchange an important metal, mercury, has been making price history, for the quotation has set up a new record at £90 per flask. The value has been moving up, both here and in the United States, for many months, mainly due to the persistent buying by the U.S. Government.

Other non-ferrous metals are firm in value; nickel is prominent in this respect, while there is no talk of any reduction in aluminium. Last week saw a gain of £3 10s. in tin, both positions being equally affected. The week closed with a backwardation of £2. Lead gained £1 for the current month and 30s. for August, while zinc improved by 15s. and 25s. for the respective positions.

Little change was seen in the cash price of copper, which closed 5s. higher, but three months improved by 25s., the backwardation being no more than £2 10s. at the close of business on Friday afternoon. The copper situation has certainly improved this year and in the States there has been a steady increase in the rate of use.

Outside the States, too, some improvement has occurred; in April, production of crude copper was up by 1,800 short tons at 125,800 tons, but the output of refined copper, at 87,800 tons, compared with 93,900 tons in March, was some 6,000 tons down. Deliveries of refined copper to consumers, however, advanced from 93,300 tons in March to 99,000 tons in April, a gain of 5,700 tons.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* May 27, £240 15s. to £241 5s.; May 28, £241 10s. to £242; May 31, £240 15s. to £241; June 1, £240 10s. to £240 15s.; June 2, £240 5s. to £240 10s.

Three Months: May 27, £237 15s. to £238; May 28, £238 10s. to £238 15s.; May 31, £238 10s. to £238 15s.; June 1, £238 5s. to £238 10s.; June 2, £237 15s. to £238.

TIN, Standard—*Cash:* May 27, £720 to £722 10s.; May 28, £728 to £729; May 31, £720 to £721; June 1, £724 to £725; June 2, £728 to £729.

Three Months: May 27, £719 to £720; May 28, £726 10s. to £727; May 31, £720 to £721; June 1, £722 10s. to £723; June 2, £726 10s. to £727.

ZINC—*May:* May 27, £79 12s. 6d.; to £79 15s.; May 28, £80 to £80 2s. 6d. *June:* May 31, £80 7s. 6d. to £80 10s.; June 1, £81 7s. 6d. to £81 12s. 6d.; June 2, £81 12s. 6d. to £81 15s.

August: May 27, £79 17s. 6d. to £80; May 28, £80 5s. to £80 10s. *First half September:* May 31, £80 10s. to £80 15s.; June 1, £81 10s. to £81 15s.; June 2, £81 12s. 6d. to £81 15s.

LEAD—*May:* May 27, £95 to £95 5s.; May 28, £95 15s. to £96. *First half June:* May 31, £96 10s. to £97; June 1, £97 15s. to £98 5s.; June 2, £99 to £99 10s.

Second half August: May 27, £94 5s. to £94 10s.; May 28, £94 15s. to £95. *First half September:* May 31, £95 5s. to £95 10s.; June 1, £96 5s. to £96 10s.; June 2, £97 to £97 10s.